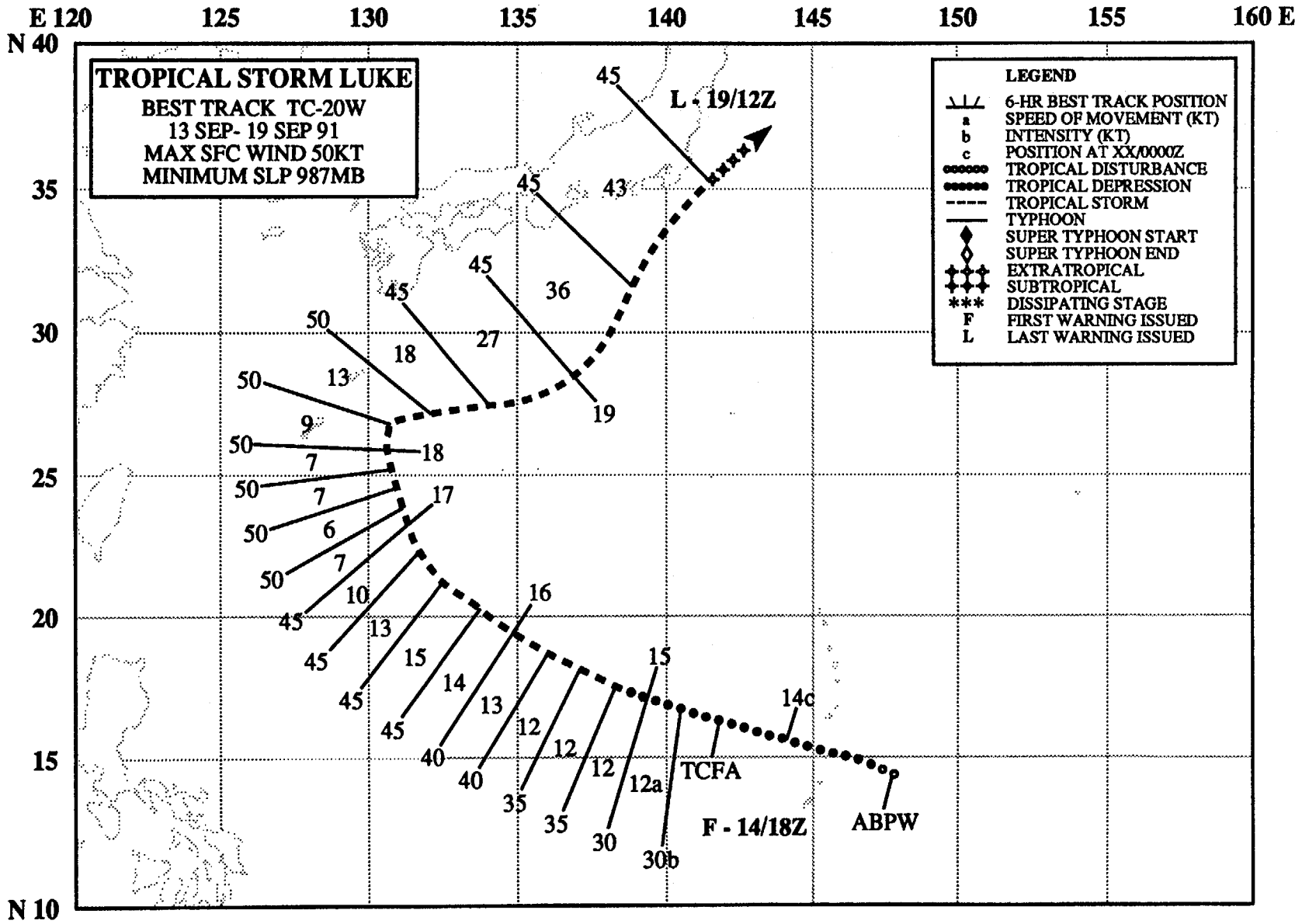

E 120
125
130
135
140
145
150
155
160 E
N 40
35
30
25
20
15
N 10
102
TROPICAL STORM LUKE
BEST TRACK TC-20W
13 SEP- 19 SEP 91
MAX SFC WIND 50KT
MINIMUM SLP 987MB
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
*** DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
L - 19/12Z
F - 14/18Z
TCFA
ABPW
45
43
36
27
19
18
13
9
50
7
6
17
10
16
15
14
12
12a
30b
14c
40
35
30

TROPICAL STORM LUKE (20W)

I. HIGHLIGHTS

Tropical Storm Luke (20W), a broad monsoonal cyclone, had the largest initial position errors of the season. Its unusual recurvature track was the result of an extension of the mid-latitude westerlies deep into the tropics in mid-September, which temporarily broke down the subtropical ridge in the western Pacific.

II. TRACK AND INTENSITY

Luke formed from a disturbance that passed near Saipan late on 14 September. It was initially mentioned on the 130600Z Significant Tropical Weather Advisory. As the disturbance tracked west-northwestward, improved upper-level anticyclonic outflow and sea-level pressure falls of 3 mb led to the issuance of a Tropical Cyclone Formation Alert at 141130Z. At 141800Z, the first warning on Tropical Depression 20W was issued when the synoptic data indicated that a closed circulation had developed. At this time, Luke was a monsoon depression, with a ring of 30 kt (15 m/sec) winds around a large central area of light and variable winds. The cyclone continued to slowly intensify over the next 48 hours as it tracked west-northwestward. On 17 September, satellite imagery indicated that the circulation had lost organization, and that it appeared to be moving westward, but on 18 September an exposed low-level circulation revealed that the tropical storm had, in fact, turned north-northwestward (Figure 3-20-1). Shortly afterward, Luke made another sharp change in direction to the east as a mid-tropospheric trough brought westerly winds deep into the tropics and caused the subtropical ridge,

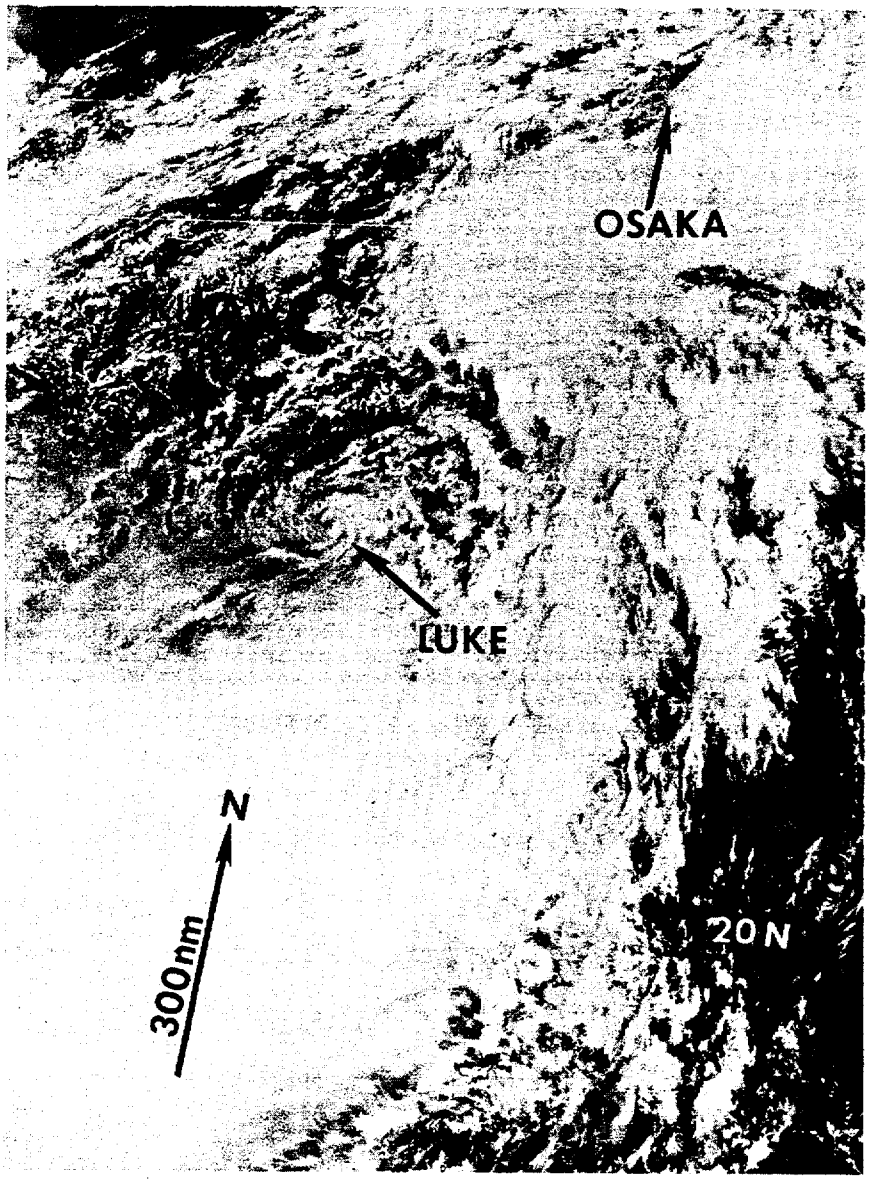
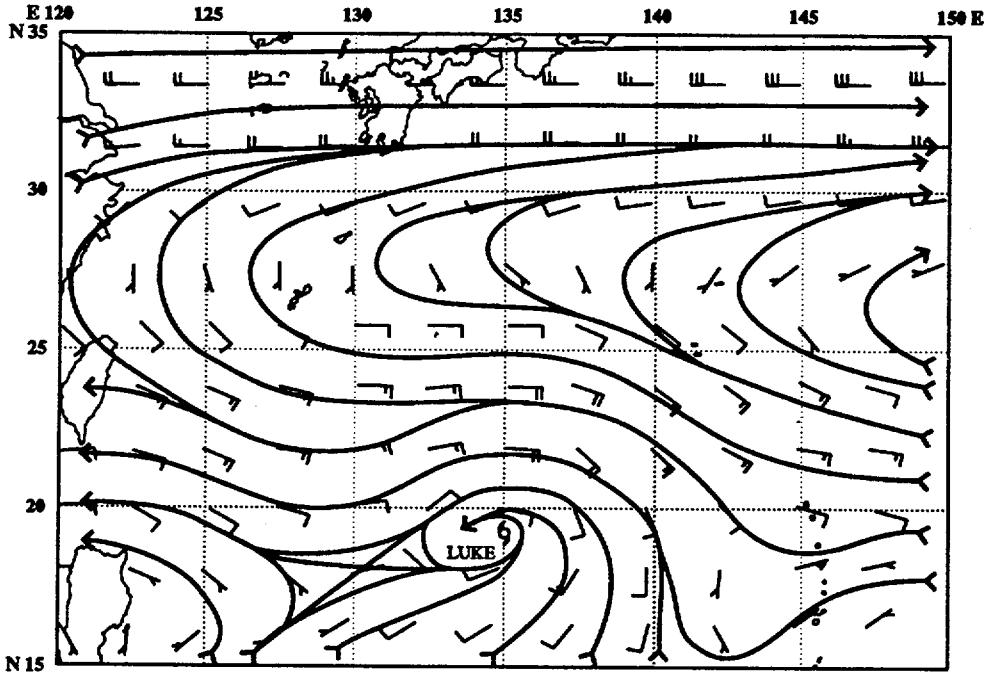


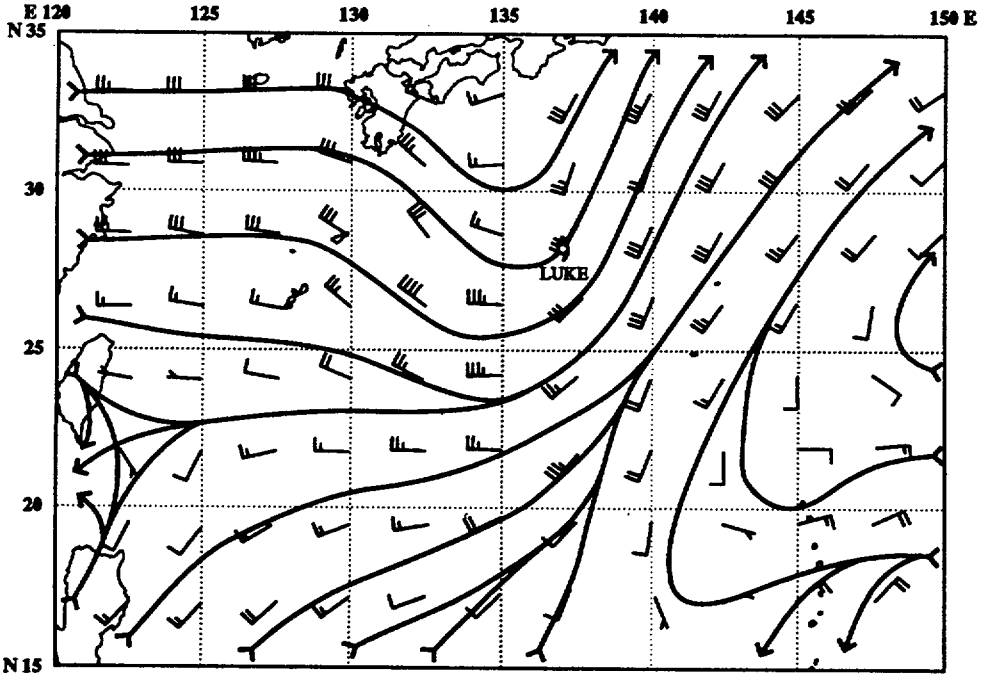
Figure 3-20-1. The exposed low-level center of Tropical Storm Luke as it makes its closest point of approach 160 nm (295 km) east of Okinawa (172336Z September DMSP visual imagery).

which had been holding the system to a westward track, to recede eastward (Figure 3-20-2). Meanwhile, the vertical wind shear between Luke and the westerlies scrambled the cloud pattern during the evening hours. This left JTWC attempting to extrapolate a track to the north-northwest, while the obscured low-level circulation of Luke (Figure 3-20-3) was actually accelerating northeastward and transitioning into an extratropical cyclone. This misinterpretation caused JTWC forecasters to issue an unnecessary Tropical Cyclone Formation Alert at 181500Z on a peripheral convective area. The alert was canceled at 190400Z. The final warning on Tropical Storm Luke was issued at 191200Z.

III. FORECAST PERFORMANCE



(a)



(b)

Figure 3-20-2. NOGAPS Deep-layer mean analyses at (a) 160000Z and (b) 190000Z September. Note the dramatic change in the extent of the subtropical ridge axis during the 72-hour period as mid-latitude westerlies associated with a passing trough penetrated unusually far equatorward.

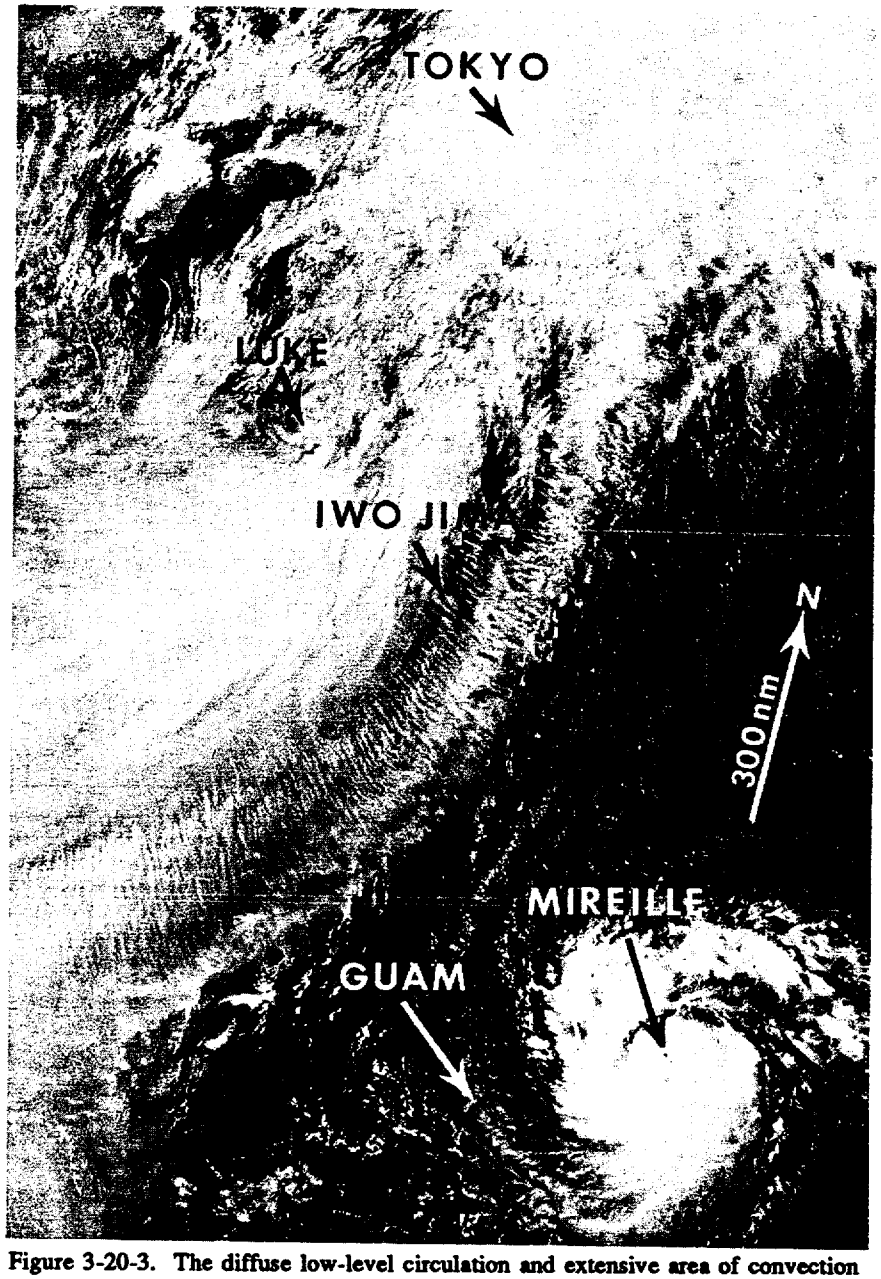
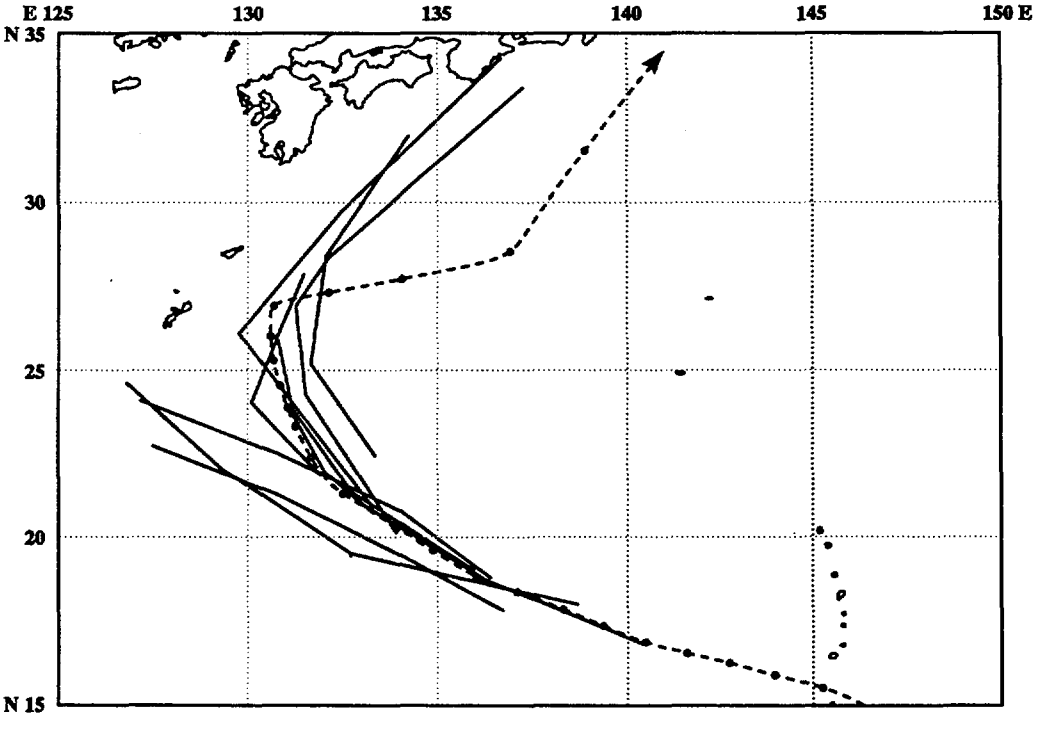


Figure 3-20-3. The diffuse low-level circulation and extensive area of convection associated with Luke as it undergoes extratropical transition south of Honshu. Typhoon Mireille (21W) appears at the lower right of the picture (182314Z September DMSP visual imagery).

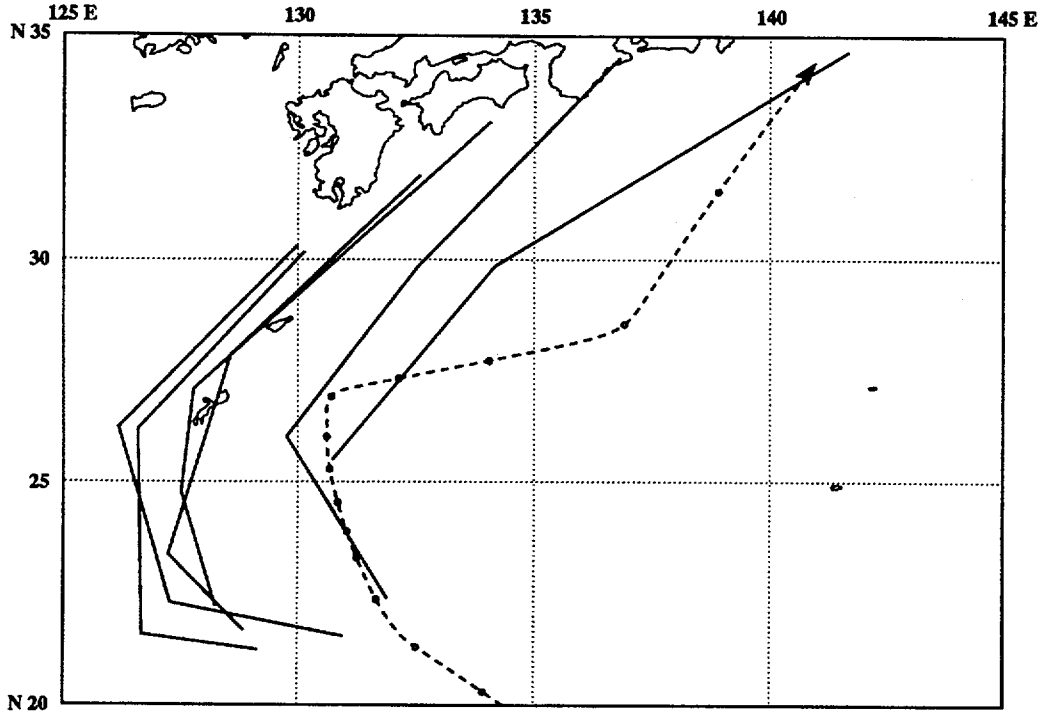
On 17 and 18 September, uncertainty over the initial warning positions of Tropical Storm Luke underscored the limitations that can occur in locating a poorly defined cloud system center from only infrared satellite images, and the effect these limitations can have on JTWC warnings. A comparison of JTWC forecasts with the verifying best track graphically illustrates where erroneous initial positions misled JTWC forecasts (Figure 3-20-4). Until 161800Z, JTWC warnings were in agreement that Luke would recurve east of Okinawa and head toward Honshu ahead of an approaching mid-tropospheric trough. These warnings accurately represented the future path of the cyclone and had low forecast errors. Starting at 170000Z, forecasters adopted the scenario that the system was moving westward, causing the recurvature forecast tracks to be adjusted further westward, threatening Okinawa. A relocation of the warning position at 180000Z was too late to prevent the evacuation of some aircraft from Kadena AB on Okinawa. Another major relocation of the cyclone occurred at 190000Z because of the significant track change which occurred during the nighttime. Using infrared imagery, satellite analysts had a challenging task locating the poorly defined circulation center residing beneath a dense cloud shield. In turn, JTWC's extrapolation of the perceived short-term motion resulted in large forecast errors.

IV. IMPACT

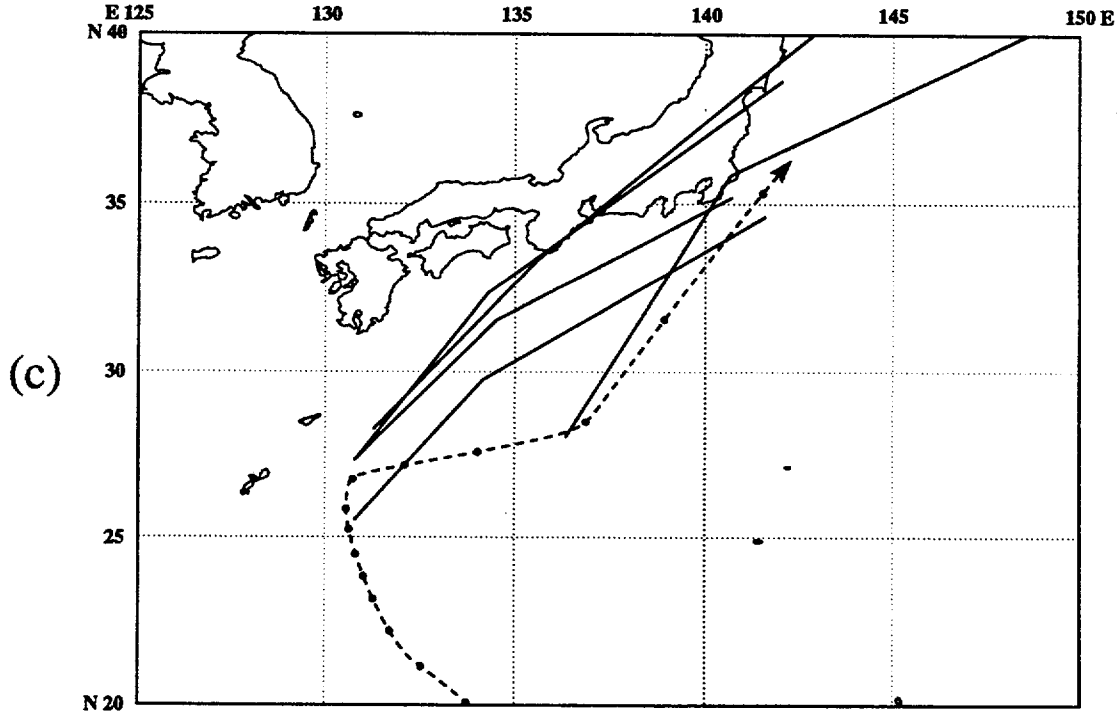
Although Luke did not attain typhoon intensity, its broad area of gale-force winds and torrential rains affected large portions of the western Pacific. On 17 September, JTWC forecasts resulted in the unnecessary evacuation of aircraft stationed at Kadena AB, costing an estimated $300,000. Later, on 19 September, record rainfall from Luke caused extensive flooding in central Japan, resulting in the deaths of at least 8, with 10 other people reported missing and damage to 28,000 homes.



(a)



(b)



(c)

Figure 3-20-4. Comparison of the oficial forecast to the final best track for (a) 141800Z to 161800Z, (b) 161800Z to 180000Z, and (c) 180600Z to 190000Z September.